(19) Europäisches Patentamt
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(11) EP 0 921 006 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.06.1999 Bulletin 1999/23

(51) Int Cl.[6]: **B41J 2/21**

(21) Application number: **98309422.8**

(22) Date of filing: **18.11.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **05.12.1997 US 985641**

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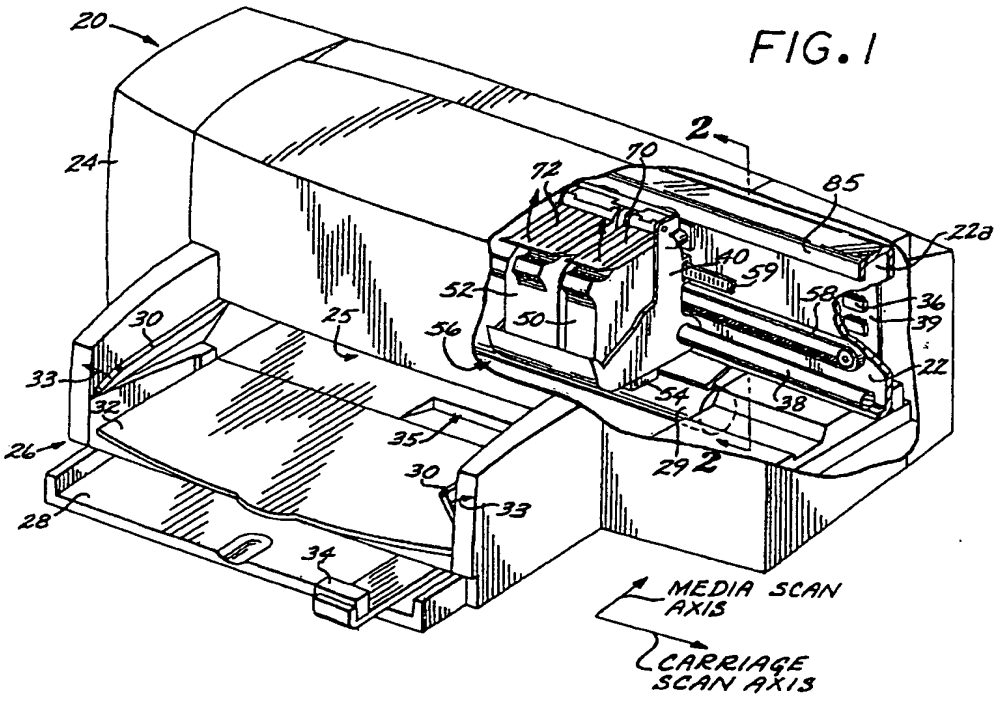
(54) Printer assembly

(57) A printer (20) includes a movable print carriage (40) for reciprocatingly scanning along a carriage scan axis, a printhead (54, 56) having a plurality of ink jet nozzles and supported by the movable print carriage, a print media moving mechanism (29) for moving print media along a media axis through a print zone (25), and a vibration inducing piezoelectric element (61) for causing relative vibration between the printhead (54, 56) and the print media such that locations along a media axis of dots printed by the ink jet nozzles are minutely randomly varied to reduce otherwise visible banding caused by poor paper advance or misdirected nozzles.

FIG. 1



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Descripti n

[0001] The disclosed invention relates to a printer including a vibration inducing element.

[0002] An ink jet printer forms a printed image by printing a pattern of individual dots at particular locations of an array defined for the printing medium. The locations are conveniently visualized as being small dots in a rectilinear array. The locations are sometimes called "dot locations," "dot positions," or "pixels". Thus, the printing operation Can be viewed as the filling of a pattern of dot locations with dots of ink.

[0003] Ink jet printers print dots by ejecting very small drops of ink onto the print medium, and typically include a movable print carriage that supports one or more printheads each having ink ejecting nozzles. The print carriage traverses back and forth over the surface of the print medium, and the nozzles are controlled to eject drops of ink at appropriate times pursuant to command of a microcomputer or other controller, wherein the timing of the application of the ink drops is intended to correspond to the pattern of pixels of the image being printed. Typically, a plurality of rows of pixels are printed in each traverse or scan of the print carriage. The particular ink ejection mechanism within the printhead may take on a variety of different forms known to those skilled in the art, such as those using thermal printhead or piezoelectric technology. For instance, two earlier thermal ink jet ejection mechanisms are shown in commonly assigned U.S. Patent Nos. 5,278,584 and 4,683,481. In a thermal system, an ink barrier layer containing ink channels and ink vaporization chambers is disposed between a nozzle orifice plate and a thin film substrate. The thin film substrate typically includes arrays of heater elements such as thin film resistors which are selectively energized to heat ink within the vaporization chambers. Upon heating, an ink droplet is ejected from a nozzle associated with the energized heater element. By selectively energizing heater elements as the printhead moves across the print medium, ink drops are ejected onto the print medium in a pattern to form the desired image.

[0004] A consideration scanning carriage ink jet printers is the visible banding caused by poor paper advance or misdirected in nozzles. Such banding has been addressed by software randomization. However, software randomization has been found to require multiple passes, wherein the number of passes increases with the inaccuracy of the paper advance. This significantly reduces throughput.

[0005] The present invention seeks to provide improved printing.

[0006] According to an aspect of the present invention, there is provided a printer as specified in claim 1.

[0007] The preferred embodiment can provide an ink jet printer having reduced print banding caused by poor paper advance or misdirected nozzles and print banding reduction that does not substantially reduce throughput.

[0008] The preferred embodiment provides a printer which includes a movable print carriage for reciprocatingly scanning along a carriage scan axis, a printhead having a plurality of printing elements and supported by the movable print carriage, a print media moving mechanism for moving print media along a media axis through a print zone, and a vibration inducing element for causing relative vibration between the printhead and the print media such that locations along the media axis of dots printed by the printing elements are minutely randomly varied. In accordance with a specific implementation, the vibration inducing element includes a piezoelectric element.

[0009] An embodiment of the present invention is described below, by way of example only, with reference to the accompanying drawings, in which:

[0010] FIG. 1 is a partially fragmented schematic perspective view of an ink jet printing mechanism that employs random noise vibration.

[0011] FIG. 2 is a side elevational view of the print carriage of the printing mechanism of FIG. 1.

[0012] FIG. 3 is a bottom plan view of the print carriage of the printing mechanism of FIG. 1 showing the printheads of the print cartridges disposed in the print carriage.

[0013] FIG. 4 is a schematic perspective view of the print carriage of the printing mechanism of FIG. 1.

[0014] FIG. 5 is a top plan view of the print carriage of the printing mechanism of FIG. 1.

[0015] Referring now to FIG. 1, set forth therein is a schematic partially fragmented perspective view depicting, by way of illustrative example, major mechanical components of a swath type ink jet printer 20 employing random noise vibration. The printer includes a chassis 22 surrounded by a housing or enclosure 24, typically of a molded plastic material. The chassis 22 is formed for example of sheet metal and includes a vertical panel 22a. An example of a printer is the Hewlett-Packard Company's DeskJet 722 brand ink jet printer.

[0016] Sheets of print media are individually fed through a print zone 25 by an adaptive print media handling system 26 that includes a feed tray 28 for storing print media before printing. The print media may be any type of suitable printable sheet material such as paper, card-stock, transparencies, mylar, and the like, but for convenience the illustrated embodiments described as using paper as the print medium. A series of conventional motor-driver rollers including a drive roller 29 driven by a stepper motor may be used to move print media from the feed tray 28 into the print zone 25, as shown in FIG. 2 for sheet 37, for printing. After printing, the drive roller 29 drives the printed sheet onto a pair of retractable output drying wing members 30 which are shown extended to receive a printed sheet. The wing members 30 hold the newly printed sheet for a short time above any previously printed sheets still drying in an output tray 32 before pivotally retracting to the sides, as shown by curved arrcws 33, to drop the newly printed sheet into

the output tray 32. The print media handling system may Include a series of adustment mechanisms for accommodating different sizes of print media, including letter, legal, A-4, envelopes, etc., such as a sliding length adjustment arm 34 and an envelope feed slot 35.

[0017] The printer of FIG. 1 further includes a printer controller 36, schematically illustrated as a microprocessor, disposed on a printed circuit board 39 supported on the rear side of the chassis vertical panel 22a. The printer controller 36 receives instructions from a host device such as a personal computer (not shown) and controls the operation of the printer including advance of print media through the print zone 25 and the ink jet printing of dots, discussed further herein.

[0018] A print carriage slider rod 38 having a longitudinal axis parallel to a carriage scan axis is supported by the chassis 22 to slideably support a print carriage 40 for reciprocating translational movement or scanning along the carriage scan axis.

[0019] As more particularly shown in FIGS. 2-5, the print carriage 40 more particularly includes a body portion 75 having a rear wall 185, a front apron 186, and L-shaped side walls 174, 176 that extend forwardly from lateral edges of the rear wall 185 to lateral edges of the front apron 186. An alignment wall or web 76 divides an interior portion of the carriage body into first and second chambers 80, 82 which respectively house first and second removable ink jet printhead cartridges 50, 52 (each of which is sometimes called a "pen," "print cartridge," or "cartridge"). The print cartridges 50, 52 include respective printheads 54, 56 that respectively have generally downwardly facing nozzles for ejecting ink generally downardly onto a portion of the print media 37 that is in the print zone 25. A latch mechanism that includes clamping levers, latch members or lids 70, 72 pivotally attached by a hinge 74 to the body portion 75 of the print carriage 51 cooperatively acts with the print carriage body 75 and the print cartridges 50, 52 to clamp the cartridges 50, 52 in the chambers 80, 82.

[0020] An illustrative example of a suitable print carriage is disclosed in commonly assigned U.S. Application Serial No. 08/757,009, filed 11/26/96, Harmon et al., Docket No, 10941036, incorporated herein by reference.

[0021] For reference, the print media 37 is advanced through the print zone 25 along a media axis which is parallel to the tangent to the portion of the print media 37 that is beneath and traversed by the nozzles of the cartridges 50, 52. If the media axis and the carriage axis are located on the same plane, as shown in FIG. 1, they would be perpendicular to each other.

[0022] The print carriage 40 further includes a pair of bearings 55 which slidably support the print carriage 40 as it slides along the slider rod 38. A vertical anti-rotation guide arm 81 is attached to the back of the rear wall 185 of the print carriage body 75 and includes a slide bushing 83 that engages a horizontally disposed anti-pivot bar 85 that is formed integrally with the vertical panel 22a of the chassis 22, for example. The bearings 55 and the slide bushing 83 provide a three-point carriage support system; and the vertical anti-rotation guide arm 81, the slide bushing 83 and the horizontal anti-pivot bar 85 cooperate to prevent forward pivoting of the print carriage 40 about the slider rod 38.

[0023] By way of illustrative example, the print cartridge 50 is a monochrome printing cartridge while the print cartridge 52 is a tri-color printing cartridge. Alternatively, discrete monochrome cartridges may be used.

[0024] The print carriage 40 is driven along the slider rod 38 by an endless belt 58 which can be driven in a conventional manner, and a linear encoder strip 59 is utilized to detect position of the print carriage 40 along the carriage scan axis, for example in accordance with conventional techniques.

[0025] A vibration inducing element, which in this example vibrates at a frequency in the range of about 100 Hz to about 1000 Hz, is provided to induce a vibration of very small amplitude along the media axis between the printheads and the print media as the carriage traverses the print media. By way of illustrative example, the vibration inducing element comprises a piezoelectric element 61 disposed between the vertical guide arm 81 and the rear wall 185 of the carriage body 75. A voltage is applied to the piezoelectric element 61 which causes the carriage 40 to rotationally vibrate about the slider rod 38. As a result of such rotational vibration, the aim or direction of the nozzles of the printheads 54, 56 is vibrationally angularly varied over a small angle in a plane that is orthogonal to the media carriage axis. As a result of the vibrational angular variation, the potential placement of dots along the media axis is vibratingly varied over a small interval, whereby the actual placement of dots along the media axis is vibratingly varied over such small interval. By way of illustrative example, the print carriage 40 and the piezcelectric element are configured to provide a dot placement variation of about 6.4μm (about .25 of 1/1000th of an inch).

[0026] Effectively, this embodiment intrcducing a small amount of mechanical noise into the placement of dots along the media axis, which reduces visible banding that would otherwise be caused by less than optimal paper advance or nozzle aim since the small amount of mechanical noise vibrates the placement of the dots that would otherwise define the bands. It should be appreciated that the sharpness of the printed image may be slightly degraded in exchange for reduced banding, and vibration inducing element may be selectively enabled and disabled.

[0027] While a piezoelectric element is disclosed as the vibrational noise introducing element, other apparatus such as a small electric eccentric motor (frequently used in pagers as a silent vibrator) can be used. As shown in FIG. 4 by way of illustrative example, a small eccentric motor 161, schematically depicted in broken lines, can be conveniently attached to the wall 174 of the carriage body 40. Operation of the motor 161, which

includes an eccentric load or mass 161a, causes micro-rotation of the carriage 40 about the slider rod 38 which in turn causes micro-displacement the placement of the printed dots.

[0028] The foregoing has been a disclosure of an ink jet printer that advantageously utilized mechanical noise to reduce banding caused by poor paper advance or misdirected ink jet nozzles, and more generally of a mechanical print banding reducing technique that is readily adapted to various printers.

[0029] The disclosures in United States patent application no. 08/985,641, from which this application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

Claims

1. A printer comprising:

   a movable print carriage (40) for reciprocatingly scanning along a carriage scan axis;
   a printhead (54, 56) supported by said movable print carriage and including a plurality of printing elements for printing on print media in a print zone (25) ; and
   a vibration inducing element (61) for causing said printhead to vibrate relative to print media in the print zone such that locations along a media axis of dots printed by said printing elements are minutely substantially randomly varied.

2. A printer as in claim 1, wherein said vibration inducing element (61, 161) is coupled to said print carriage (40).

3. A printer as in claim 1 or 2, wherein said vibration inducing element (61, 161) is operable to vibrate at a frequency in the range of about 100 Hz to about 1000 Hz.

4. A printer as in claim 1, 2 or 3, wherein said vibration inducing element comprises a piezoelectric element (61) or an electric motor (161).

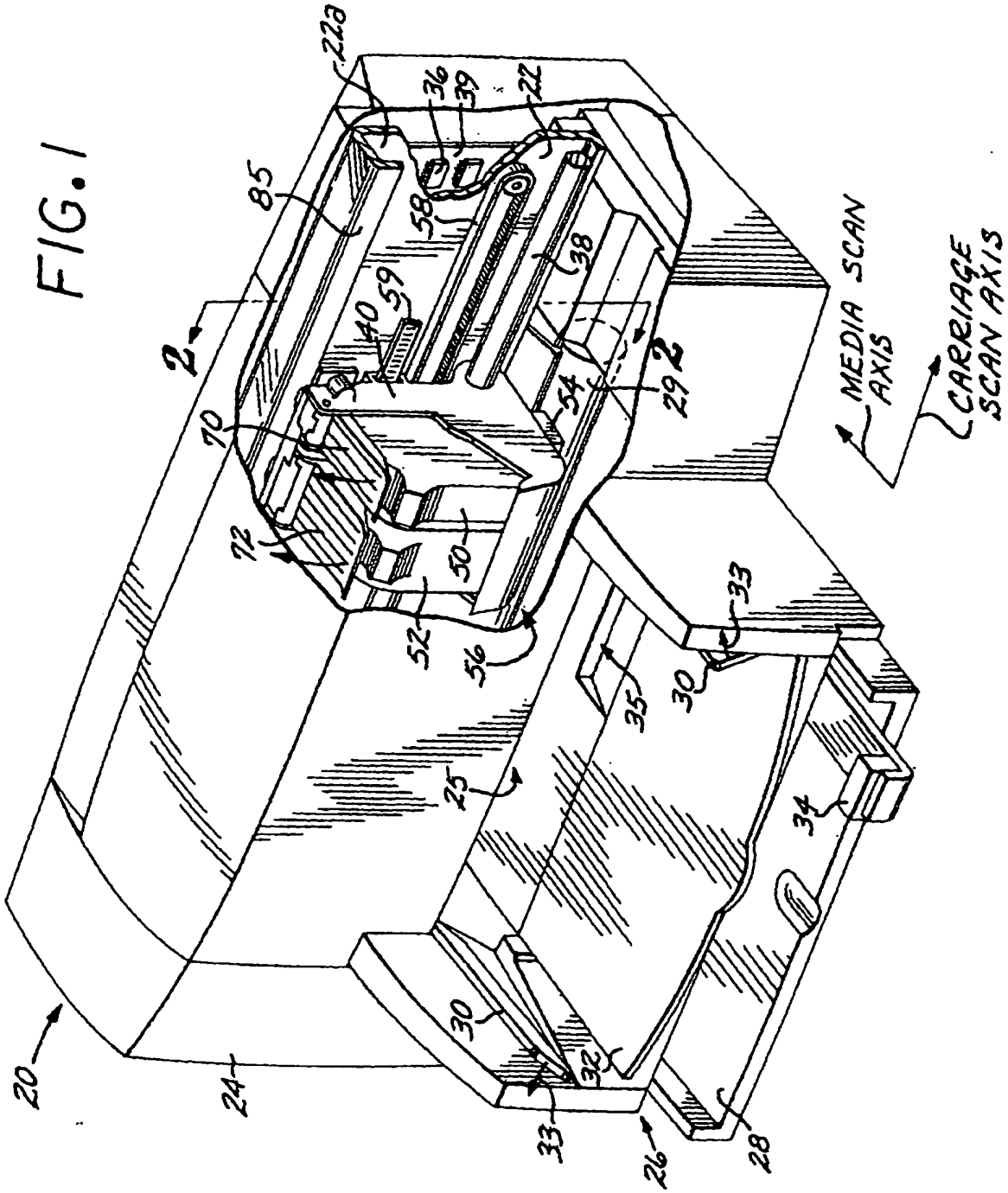
5. A printer as in any preceding claim, wherein said print elements comprise ink jet nozzles.

6. A printer as in claim 5, wherein said vibration inducing element (61, 161) is operable to vibrate said ink jet nozzles rotatingly about an axis parallel to the carriage scan axis.

7. A method of printing with a printer which comprises a movable print carriage (40) for reciprocatingly scanning along a carriage scan axis and a printhead (54, 56) supported by said movable print carriage and including a plurality of printing elements for printing on print media in a print zone (25); the method including the step of causing said printhead to vibrate relative to print media in the print zone such that locations along a media axis of dots printed by said printing elements are minutely substantially randomly varied.

8. A method as in claim 7, wherein said printhead is caused to vibrate at a frequency in the range of about 100 Hz to about 1000 Hz.

FIG. 1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MEDIA SCAN AXIS
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FIG.2

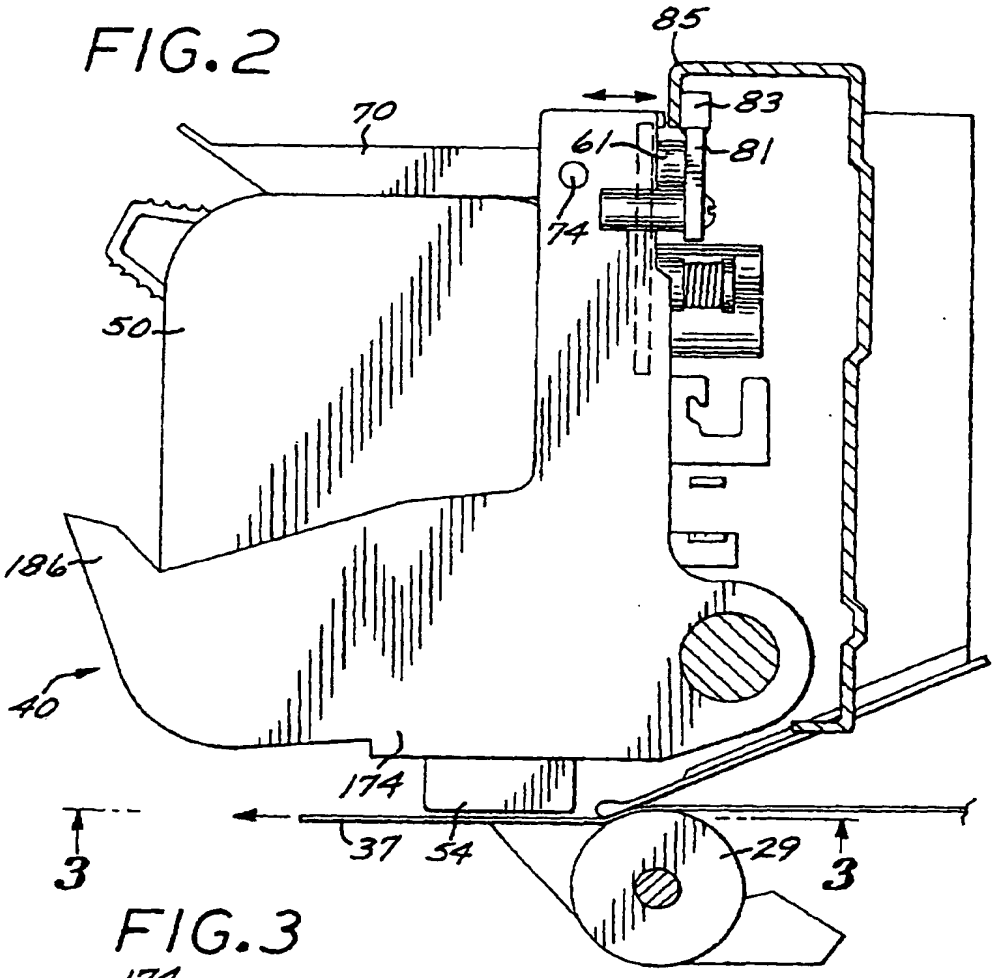
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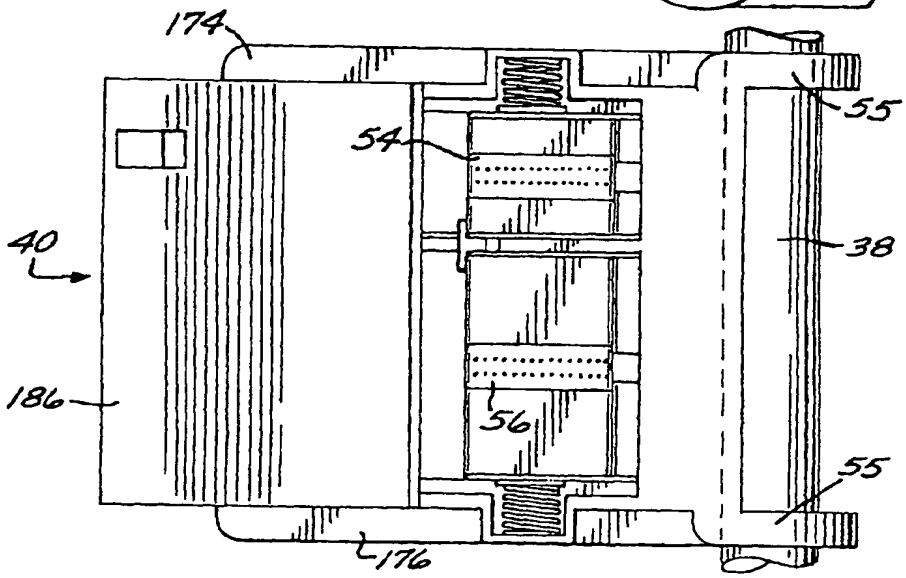
FIG.3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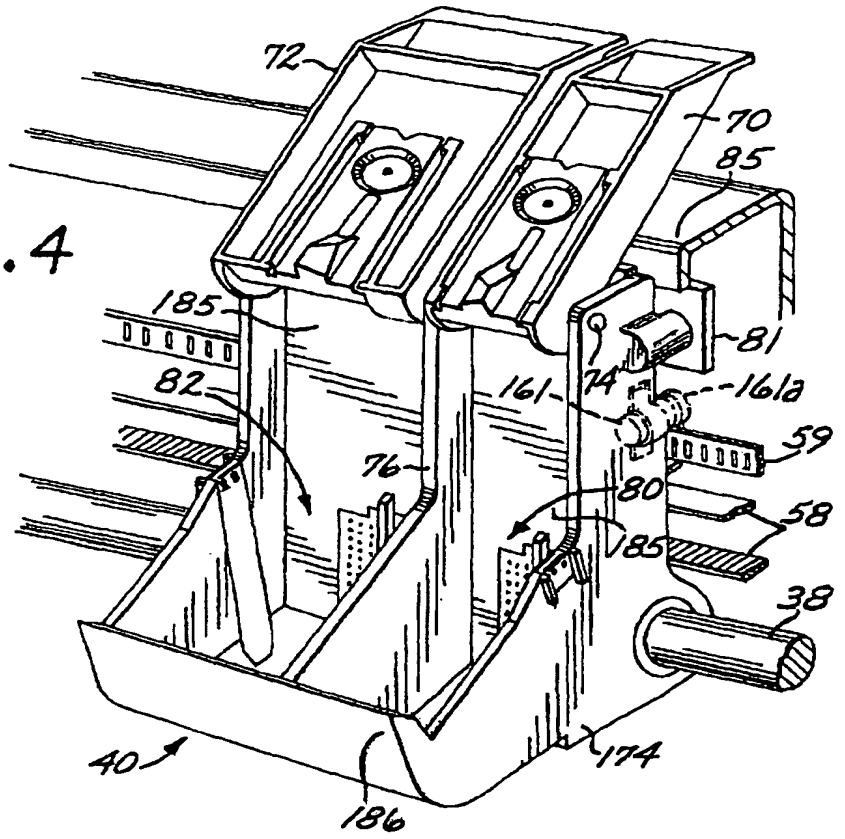
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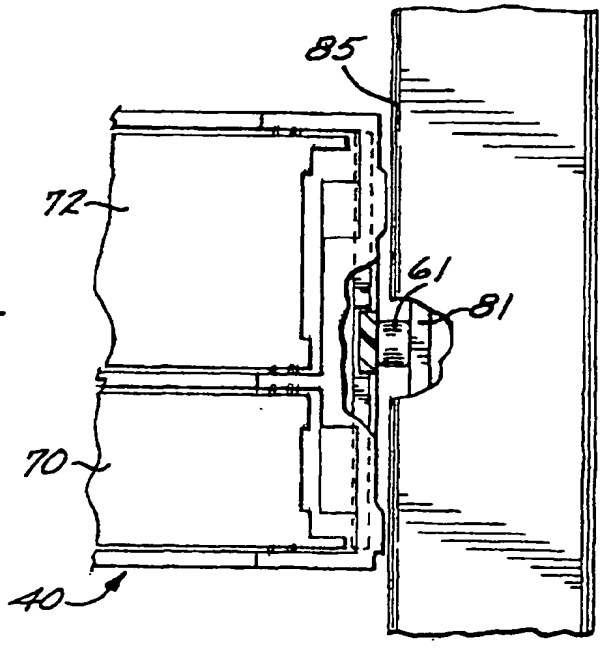
FIG.5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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 9422

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 008, no. 043 (M-279), 24 February 1984 & JP 58 199165 A (CANON KK), 19 November 1983 * abstract *	1,5,7	B41J2/21
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 211 (M-243), 17 September 1983 & JP 58 107356 A (SANYO DENKI KK), 27 June 1983 * abstract *	1,2,4-7	
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 211 (M-243), 17 September 1983 & JP 58 107359 A (SANYO DENKI KK), 27 June 1983 * abstract *	1,2,4-7	
X	PATENT ABSTRACTS OF JAPAN vol. 011, no. 301 (M-628), 30 September 1987 & JP 62 092866 A (CANON INC), 28 April 1987 * abstract *	1,2,4	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B41J
X	PATENT ABSTRACTS OF JAPAN vol. 009, no. 179 (M-399), 24 July 1985 & JP 60 048368 A (CANON KK), 16 March 1985 * abstract *	1,2	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 March 1999	Didenot, B

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X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 434 (M-764), 16 November 1988 & JP 63 170060 A (CITIZEN WATCH CO LTD), 13 July 1988 * abstract *	1	
X	US 5 193 922 A (HAYASHI MIKIO) 16 March 1993 * the whole document *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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05-03-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5193922 A	16-03-1993	JP 4005055 A	09-01-1992

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